

NOTES AND COMMENTS

SURFACE VIBRATIONAL CUES IN THE PRECOPULATORY BEHAVIOR OF WHIRLIGIG BEETLES

The surface film of a body of water is much like a thin elastic membrane stretched out at the air-water interface. The physical properties of this film are responsible for water occurring in discrete drops of dew, and on larger bodies of water the surface film can support the weight of a small animal such as an insect.

The unique habitat offered by the surface film of bodies of fresh water has been occupied by relatively few invertebrates. While many insects must periodically penetrate the surface film from below to breathe or above to oviposit, permanent residents are limited to a few families of water-striding or back-swimming Hemiptera, and to the whirligig beetles (family Gyrinidae) among the Coleoptera. A few spiders, such as *Dolomedes triton* also occupy this habitat (Bleckmann and Rovner, 1984; Bleckmann and Barth, 1984). For general information about whirligig ecology, see Hatch (1925), and Kolmes (1983b).

Members of both the water-striding and back-swimming families of Hemiptera and the whirligig beetles possess specialized sensory structures enabling them to detect minute vibrational stimuli in the surface film (see Murphey, 1971a and 1971b for a discussion of *Gerris remigis*; see Murphey, 1973 and Murphey and Mendenhall, 1973 for a discussion of *Notonecta undulata*). The use of surface vibrations as precopulatory signals has been demonstrated in both *Rhagadotarsus* (Wilcox, 1972) and *Gerris remigis* (Wilcox, 1979) and is strongly suspected in *Corixa* species (Thiess, 1982) all of which live at the air-water interface. I report an investigation of the precopulatory behavior of the whirligig beetle *Dineutes discolor*, done in order to see if vibrational stimuli are utilized by these animals as well. Whirligig beetles are only distantly related to Hemiptera, but I suspected that a convergence in communicatory systems might well exist due to the animals in question occupying the same rather unusual habitat. Certain of the precopulatory behavior patterns that I have reported earlier (see descriptions of *proleg-up* and *male mounting of female beetles* in Kolmes, 1983a) appeared to be likely candidates for signals involving a surface vibrational component.

The surface vibration detectors of whirligig beetles reside in their antennae. The antennae of whirligigs are unusually shaped with a club-like antennal flagellum arising from a flattened antennal pedicel that rests on the surface film (Kolmes, 1983b). The juncture between these two antennal regions is elastic, and sensory cells detect relative movement between the flagellum and pedicel (Wilde, 1941). These sensory units, the Johnston's organs, are extremely sensitive. In some species of whirligig beetle the Johnston's organs can detect vibrations of the surface film with an amplitude of only a few microns (Rudolph, 1967).

My strategy in this experiment was simply to take whirligigs who had already demonstrated their ability to carry out precopulatory behavior leading to copulation

in the laboratory, and to remove their antennal flagellae, thereby rendering their Johnston's organs inoperative. The removal of the antennal flagellae could be rapidly carried out on beetles anaesthetized with CO₂, and no gross changes in the noncommunicatory behavior or survival of these animals resulted from this procedure. Experimental beetles continued to capture live *Drosophila* using their close circling behavior pattern (Kolmes, 1983b), and displayed all of the fifteen behavior patterns comprising my behavioral categories for *D. discolor* (Kolmes, 1983a). The beetles were housed in my laboratory individually in 1-liter aquaria, and their precopulatory behavior was observed by placing 2 male and 2 female beetles in a large observation aquarium. The beetles were collected from the Wisconsin River near Arena (Iowa Co.), Wisconsin. They were maintained in the laboratory on a diet of live flightless *Drosophila*. See Kolmes (1983a, b) for more details of my techniques for housing *Dineutes* in the laboratory.

Before these whirligigs had their antennal flagellae removed, I observed 15 copulations during 32 observation periods. Since there were 2 male and 2 female beetles present during each trial, I expressed this for analysis as 15 copulations for 64 pairs. After the beetles were deprived of their Johnston's organs, 10 observation periods resulted in no copulations. I expressed this for analysis as 0 copulations per 20 pairs. Comparing these data using a χ^2 2 × 2 contingency test (see Siegel, 1956 for details) the difference between the behavior of the animals with and without their surface vibration detectors differs reliably at $P < 0.05$ ($\chi^2 = 4.42$, $df = 1$).

Removing the antennal flagellae of a gyridid severs the three bundles of scolopidia making up each Johnston's organ (Wilde, 1941). These scolopidia produce the synchronous sum potential Rudolph (1967) found when electrophysiologically monitoring the antennal nerves of beetles subjected to surface vibrations. The removal of antennal flagellae therefore destroys the surface vibrational sensitivity mediated by gyridid Johnston's organs. Could this removal interfere with the reception of signals conveyed by other sensory systems?

Tactile hairs are the only sense organs revealed by a scanning electron microscope examination of whirligig antennal pedicels, and these hairs continue to contribute sensory input used in predatory behavior after removal of antennal flagellae (Kolmes, 1983b). No sensory systems other than those of the Johnston's organs have been described from gyridid antennal flagellae (Wilde, 1941; Rudolph, 1967) and any other sense organs present must be quite inconspicuous compared to the antennal specializations for mate detection found in many male insects.

It is likely that several sensory modalities are involved in whirligig precopulatory behavior. Whirligigs have well developed vision (Bennett, 1967; Brown and Hatch, 1929; Carthy and Goodman, 1964) and some of the potential precopulatory signals previously identified (Kolmes, 1983a) likely possess visual components. Gyridids are morphologically a very uniform group, and multispecific swarms have been described (Heinrich and Vogt, 1980). This may provide the impetus for chemically mediated species recognition cues, with male precopulatory mountings of female beetles providing a possible interaction during which contact chemoreception could occur (Kolmes, 1983a). Further experiments will be required before the contributions of signals conveyed through all of the sensory modalities of *D. discolor* can be clarified.

Clearly the main point of interest to arise from this experiment is that *Dineutes*

discolor do rely on surface vibrational sensitivity in their precopulatory behavior. My data are not adequate to point out precisely what signals my procedure interfered with, however two behavior patterns that might be involved are female proleg-up and male mountings of female beetles (Kolmes, 1983a). Both the Hemiptera specialized for life on the surface film, and whirligig beetles, have come to utilize this elastic membrane as a channel for transmitting vibratory signals.

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